J. Sus. Agric .Sci. **43,** No. 4, pp. 187 - 196 (2017)

The Role of Morphological Traits above Flag Leaf Node and Floral Traits in Hybrid Rice Seed Production

A.G. Abdel-Hafez [1], E.F.A. Arafat[2] and A.H. Matar[1]

[1]Agronomy Dept., Faculty of Agriculture, Kafr El-Sheikh University, 33516, Kafr El-Sheikh, Egypt and [2] Rice Research Section, FCRI, Agricultural Research Centre, Egypt

FLORAL traits for the parents used in hybrid rice seed production are very effective in hybrid rice seed production especially in the three line system used in this study.The longer anther, stigma and filament are, the wider anther and stigma besides high exertion ratio and angle of spikelets opening are important factors that increase the outcrossing rate which increases seed set and production. This study was conducted out at the farm of Sakha Agric. Res. Station during 2014 and 2015 seasons to contribute in choosing best CMS, maintainer and restorer lines to use in hybrid rice seed production depending on its floral traits. Also, it can be used in a breeding program for improving the floral traits of other lines that can serve as good parents in hybrid rice breeding and seed production.In brief, we found that among the studied CMS lines,Pusa13A was the best line in stigma length, angle of spikelets opening, filament length,exertion ratio (%), number of filled grains panicle^{-1}, seed set (%),panicle weight and plant yield characters, while Pusa13B line was the optimum owing to its high characters like, anther length, good filament length, high exertion ratio (%),number of filled grains panicle^{-1} and plant yield.For restorer lines, PR1 was the best in anther length, stigma length, stigma width, filament length,number of spikelets plant^{-1}, number of filled grains panicle^{-1} and panicle weight.

Keywords: CMS, Cytoplasmic male sterile line, Floral traits, Hybrid rice seed production, *Oryza sativa* L.

Introduction

In Egypt, hybrid rice became very important now to increase rice yield. It increases the yield of unit area by 20% more than commercial pure line rice varieties under normal conditions (Cheng et al., 2007).To improve hybrid rice in Egypt, it is very important to emphasize on hybrid rice seed production, which widens the base of hybrid rice cultivated area has different ways to produce. These ways are: One line, two line and three line system.However, the success of hybrid rice breeding depends on the outcrossing rate on CMS lines. Hasan et al. (2014) indicated that, understanding and studying the floral traits is very important for multiplication of CMS, F_1 seed production and counting cost of effective seed production package development.

Among attainable ways to raise the productivity of area unit above current ceiling is exploiting process of heterosis in hybrid rice, which leads to obvious breakthrough in productivity of cultivated area for Egypt (Bastawisi et al., 1998).In hybrid rice technology, most usually two sterility systems CMS and EGMS are used for commercial seed production. In three line system of hybrid rice seed production, three lines (A, B and R lines) are required. A line is the cytoplasm-genetic male sterile line where the male sterility is jointly controlled by recessive nuclear gene and sterile cytoplasm. B line is isogenic line of Aline, only different in male sterility and fertility. Restorerline possesses fertility restoration gene. Floral morphology and flowering behavior of cytoplasmic male sterile A lines and the male parents, maintainer and restorer lines decide the extent of outcrossing (Oka & Norishima, 1967 and Islam et al., 2014).

In this study, some lines used in the three line system were used to study the role of their floral and agronomic traits which have a strong effect on hybrid rice seed production. This research was conducted to study the role of morphological and floral structure traits in facilitating hybrid rice seed production.

*Corresponding author: Elsayed F. A. Arafat (Email: arafat_elsayed@yahoo.com)
DOI: 10.21608/jsas.2017.1872.1029

Materials and Methods

Two seasons field experiments were performed at the Experimental Farm of Sakha Agricultural Research Station (RRTC), Kafr El-Sheikh Governorate, Egypt during the two successive summer seasons of 2014 and 2015 with three replications in order to study the role of some floral traits which strongly affect the outcrossing rate and hybrid rice seed production in some CMS (IR68888A, IR68902A, IR70368A and Pusa13A), maintainer (IR68888B, IR68902B, IR70368B and Pusa13B) and restorer lines (PR1, PR2, PR78 and Giza 179) (Tables 1 and 2).

The parameters under study were anther length (mm), anther width (mm), stigma length (mm), stigma width (mm) and filament length (mm), which were measured by selecting five spikelets from top, middle and bottom of the panicle then measured the length and width using standard ocular micrometer under light microscope field. Opening angle of spikelet was estimated by measuring the angle between lemma and palea at the peak of its flowering (anthesis) by protractor. Panicle exertion ratio was estimated according to the following formula:

$$\text{Panicle exertion ratio} = \frac{\text{Exerted part of panicle (cm)}}{\text{panicle length (cm)}} \times 100.$$

Numbers of filled and unfilled grains. panicle^{-1} were counted in ten panicles for each line and their means were used.

Spikelets number panicle^{-1} was calculated by collecting the number of filled and empty grains panicle^{-1}.

Seed set (%) was measured using the following formula:

$$\text{Seed set (\%)} = \frac{\text{Number of filled grains/panicle}}{\text{Number of spikelets/panicle}} \times 100.$$

Panicle weight character was taken as mean weight of 10 panicles for each line in grams.

Plant yield was measured as the weight of sun dried grain yield of each individual plant. The experimental design was laid out in a randomized complete design (RCD) with three replications. All agricultural practices were applied as the optimum package of recommendation for hybrid rice seed production and CMS multiplication used in the Experimental Farm of Rice Research and Training Center, Sakha, (Anonymous, 2013).

Statistical analysis was performed using the analysis of variance technique by means of (CoStat) computer software package.

TABLE 1. Cytoplasmic male sterile lines used in the experiment

CMS line	Cytosterility source	Grain type
IR68888A and B	W A	Long
IR68902A and B	W A	Long
IR70368A and B	W A	Medium
Pusa13A, and B	W A	Long

TABLE 2. Restorer lines used in the experiment grown under Egyptian conditions

Genotype	Origin	Pedigree	Salient features
PR1	Egypt-India (Indica type)	IR58025A/Pusa basmati-1 (A x PR)	Medium maturing, semi dwarf, selender grain and aromatic restorer.
PR2	Egypt-India (Indica type)	IR58025A/Pusa basmati-1 (A x PR)	Medium maturing, semi dwarf, selender grain and aromatic restorer.
PR78	Egypt-India (Indica type)	IR58025A/Pusa basmati-1 (A x PR)	Medium maturing, semi dwarf, selender grain and aromatic restorer.
Giza 179	Egypt	GZ1368-5-S-5/GZ629612-1-2-1-1	short maturing, semi dwarf, selender grain and restorer.

Results and Discussion

Analyses of variance illustrated the presence of significant variation among the tested lines in respect to most floral characters under study. Data in Table 3 indicated that there were highly significant variations in anther length among male parents, while no significant differences were recorded for CMS lines. Anther length and width are the important characters that attributed to proper pollen quantity and pollen shedding for pollination on CMS lines (Parmar et al., 1979).

Among maintainer lines, Pusa13B line is the best line for anther length (2.37 mm) in the season of 2014 and recorded (2.32 mm) in the season of 2015. Moreover, the lowest values were obtained in anther length of IR70368B line in both seasons (2.09 and 2.02 mm, receptively). This is essential for multiplication of the CMS lines which are the female parent of hybrid rice seed (EL-Badawy, 2009). The highest value for anther length among tested restorer lines was in PR1 3.13 and 3.25 mm in the first and second years receptively, (Table 3), while the lowest was recorded for Giza 179 line (1.80 and 1.90 mm, receptively). The restorer line PR1 seems optimal for sufficient pollen production for outcrossing and enhance the hybrid seed rice production. Thus, these data clarified that PR1 has better anther length than other lines used in this study, while the lowest value of anther length among tested lines was that of Giza 179 line.

There is no need to discuss the anther length and width for CMS lines because they are sterile lines.Data in Table 3 clarified also that, there were no significant differences in anther width character for the studied CMS, maintainer and restorer lines in the two seasons.

Data indicated also, that there were significant and highly significant variations in stigma length for CMS,maintainer and restorer studied lines. Stigma length is an important trait for CMS line. Stigma receipt the pollen and long stigma are better receptors that facilitates out crossing rate of CMS line through expanding the viable area receiving the pollen grains; similar findings were reported by Jayamani and Rangaswamy (1995).

Data in Table 3 showed that the highest value for stigma length among CMS lines under study was that of IR68902A line (2.10mm) and (2.12mm) for Pusa13A line in 2014 and 2015, respectively. On the other side, the lowest value of stigma length (1.75mm) was found for IR68888A line in 2014 season and IR70368A in 2015.So, these results refer to the use of IR68902A and Pusa13A lines in hybrid seed production. Also, IR68902B line is the best one in stigma length (2.06mm) in 2014 and (1.91mm) 2015. The lowest one was recorded for IR68888B line (1.53 and 1.59mm)in both seasons, respectively. Genetic variation for stigma length had been reported to range from 0.2 to 4.2 mm among various varieties and wild species (Parmar et al., 1979 b;Virmani et al., 1980 and Bassi et al., 1992).Stigma length and width are very important traits for CMS lines (Jayamani and Rangaswamy, 1995).

The highest values of stigma length among restorer lines were 2.10 and 2.15mmfor PR1 line in the first and second season, respectively, while the lowest value (1.30mm) was recorded for Giza 179 line in the two seasons.Stigma length didn't record any significance for CMS and maintainer, just for restorer lines only.There was highly significant variation just for stigma width among restorer lines in both seasons due to environmental effects.

The highest significant values of stigma width (0.48 and 0.44mm) were recorded for PR1 in the first season and PR2 in the second season, respectively.Data in Table 4 clarified that there were significant and highly significant differences in the angle of spikelets opening among the studied lines in both seasons except for R lines, while there were significant and highly significant differences in filament length for all lines in the two seasons. Similar findings are reported by Jayamani and Rangaswamy (1995).Exertion ratio % recorded significant and highly significant variations among the studied lines for two seasons.

Virmani (1994) mentioned that there are several morphological traits of floret contributing to the hybrid rice seed production efficiency, such as size and length of stigma and style, stigma exertion, stigmatic receptivity, spikelet opening angle and duration.The highest values of spikelets opening angle were observed with IR68888A line 26.62 and 28.42 O^o in 2014 and 2015 seasons, respectively,IR68888B line (24.20 O^o) in 2014 season and (25.25 O^o) in 2015 season, while the least values were (23.17 and 21.62 O^o) with IR68902A as a CMS line, (19.67 O^o) with Pusa13B and (20.33 O^o) with IR68902B as maintainer lines in the first and second seasons, respectively (Neves et al. ,1989).

Filament length is a desirable trait for self and out pollination (EL-Badawy, 2009). It enhances the chance of anther exertion.Filament length varied significantly among the tested lines except in 2014 formaintainer lines. The highest values of filament length were observed in Pusa13B line (7.86mm) in 2014, IR68888B line (8.83mm) in 2015 and PR1 line (9.50and 9.33mm) in both seasons for maintainer and restorer lines, respectively, while the least values were recorded forIR68888B line were (6.37mm) in 2014, while in 2015,Pusa13B line showed the least value (6.83mm).Giza 179 line had 6.67 and 6.76mm filament length as restorer line in the two seasons, respectively.With respect to CMS lines, filament length has no effect on hybrid rice seed production because of its sterility, so no need to discuss it for CMS lines.

Data listed in Table 4 showed that the highest value of the exertion ratio among the CMS lines under study was 68.17% in 2014 recorded for Pusa13A line and 64.05% for IR70368A line in 2015, while the least value was that of IR68888A line 55.42 and 51.96% for 2014 and 2015, respectively.The panicles of maintainer and restorer lines being emerged completely and not covered by flag leaf, so its panicle exertion was complete in most of these lines .The earlier studies of Bassi et al. (1992) and Pardhan and Jachuck (1993), revealed significant variation for panicle exsertion among CMS lines.Data in Table 5 showed that, there were significant and highly significant variations among CMS lines, B lines and R lines in both seasons in number of spikelets plant^{-1}.

TABLE 3. Mean of anther length and width of some CMS, maintainer and restorer linesin 2014 and 2015 seasons

Line	Anther length (mm)		Anther width (mm)		Stigma length (mm)		Stigma width (mm)	
	2014	2015	2014	2015	2014	2015	2014	2015
				A line				
IR68888A	2.21	2.28	0.38	0.38	1.75b	1.94ab	0.51	0.48
IR68902A	2.28	2.18	0.45	0.40	2.10a	2.02a	0.53	0.45
IR70368A	2.05	2.05	0.42	0.39	1.80b	1.75b	0.56	0.56
Pusa13A	2.38	2.34	0.41	0.38	2.07a	2.12a	0.51	0.48
F test	ns	ns	ns	ns	**	*	ns	ns
L.S.D$_{0.05}$	___	___	___	___	0.07	0.20	___	___
L.S.D$_{0.01}$	___	___	___	___	0.10	___	___	___
				B line				
IR68888B	2.12bc	2.14b	0.47	0.54	1.53c	1.59b	0.46	0.42
IR68902B	2.20b	2.10bc	0.51	0.44	2.06a	1.91a	0.45	0.43
IR70368B	2.09c	2.02c	0.45	0.54	1.60c	1.61b	0.51	0.51
Pusa13B	2.37a	2.32a	0.48	0.50	1.86b	1.68b	0.45	0.47
F test	**	**	ns	ns	**	*	ns	ns
L.S.D$_{0.05}$	0.08	0.11	___	___	0.16	0.23	___	___
L.S.D$_{0.01}$	0.12	0.16	___	___	0.24	___	___	___
				R line				
PR1	3.13a	3.25a	0.57	0.56	2.10a	2.15a	0.48a	0.43a
PR2	2.99a	2.93b	0.57	0.48	1.95a	1.97ab	0.46ab	0.44a
PR78	3.00a	3.09ab	0.49	0.45	1.79a	1.75b	0.42b	0.41a
G.179	1.80b	1.90c	0.45	0.50	1.30b	1.30c	0.32c	0.34b
F test	**	**	ns	ns	**	**	**	**
L.S.D$_{0.05}$	0.40	0.19	___	___	0.31	0.22	0.06	0.04
L.S.D$_{0.01}$	0.60	0.29	___	___	0.48	0.33	0.09	0.05

*, ** Significant at 0.05 and 0.01 levels, respectively

TABLE 4. Mean of angle of spikelets opening, filament length and panicle exertion ratio (%) of some CMS, maintainer and restorer lines in 2014 and 2015 seasons

Line	Angle of spikelets O°		Filament length (mm)		Exertion ratio (%)	
	2014	2015	2014	2015	2014	2015
			A line			
IR68888A	26.62a	28.42a	5.25a	4.28ab	55.42c	51.96b
IR68902A	23.17c	21.62b	3.08b	3.56b	56.32c	63.90a
IR70368A	25.00b	26.00a	4.87a	5.15a	64.08b	64.05a
Pusa13A	24.93b	26.50a	4.50a	4.92a	68.17a	63.27a
F test	**	*	*	*	**	**
$L.S.D_{0.05}$	1.29	3.52	1.29	0.98	2.04	3.42
$L.S.D_{0.01}$	1.95	___	___	___	3.09	5.19
			B line			
IR68888B	24.20a	25.25a	6.37b	8.83a	103.38c	100.33a
IR68902B	20.00b	20.33c	7.67a	7.09b	96.29d	96.05b
IR70368B	24.15a	23.10b	7.67a	8.56a	110.59a	101.67a
Pusa13B	19.67b	23.67b	7.86a	6.83b	106.99b	102.31a
F test	**	**	**	*	**	**
$L.S.D_{0.05}$	1.62	1.22	0.71	1.39	2.92	2.59
$L.S.D_{0.01}$	2.45	1.85	1.07	___	4.43	3.92
			R line			
PR1	20.5	22.17	9.50a	9.33a	105.46b	96.70b
PR2	21	20.5	7.92b	8.67a	104.78b	104.10a
PR78	16.67	18.75	9.25a	9.14a	108.64a	103.34a
G.179	20.83	22.67	6.67b	6.76b	103.18b	102.52a
F test	ns	ns	**	*	**	*
$L.S.D_{0.05}$	___	___	1.27	1.39	2.38	4.83
$L.S.D_{0.01}$	___	___	1.92	___	3.61	___

*, ** Significant at 0.05 and 0.01 levels, respectively

The number of filled grains panicle^{-1},the number of unfilled grains panicle^{-1} and seed set percentage characters exhibited highly significant variations in all CMS lines, but B and R lines had significant and highly significant differences in the number of filled grains panicle^{-1} in the two seasons, while no significant differences for the number of unfilled grains panicle^{-1} or seed set rate characters were recorded. Present observations are in close agreement with the earlier report of Virmani et al. (1981).Data in Table 5 showed also that the highest values of total number of spikelets were 247.08 and 249.00 for IR68902A line as a CMS line, 238.33 and 212.00 for IR68902B line in 2014and 2015 seasons, respectively as a maintainer line. However, it was 235.30 and 221.33 spikelets panicle^{-1}for IR68888B in both seasons, respectively. PR1 gave the highest value as a restorer line (211.45 and 226.50) in 2014 and 2015 seasons, respectively, while the number of spikelets was 212.43 and 216.34 for IR70368A line as a CMS line,203.08 and 186.00 with IR70368B line as a maintainer line and 118.04 and 123.38 for Giza179 as a restorer line in the two seasons, respectively showing a low number of spikelets panicle^{-1}.

The number of filled grains varied from line to another. The highest value was recorded for Pusa13A line (114.83 and 117.71) respectively in the two seasons, as CMS line compared with the other CMS lines, IR68888B line (211.46 and 200.00) as a maintainer line and (176.42 and 159.83) with PR1 and PR78 as a restorer lines in 2014 and 2015 seasons, respectively, while the least values of filled

grains were 32.83 and 33.63 for IR68902A as CMS line, 159.67 and 163.00 for IR70368B as a maintainer line and105.46 and 104.46 , respectively for Giza 179 as a restorer line in the two seasons, . These results were consistent with the results obtained by Srivastava and Seshu (1982), Govindraj (1983) and Sahaietal. (1987).With respect to seed set percentage, the data clarified that, there were highly significant variations among CMS lines, while maintainer and restorer lines did not record any significant effective variations. Cheng et al. (2007) reported that to enhance the efficiency of hybrid seed production, it is necessary to increase the amount of hybrid seed by improving the out crossing capacity of the CMS lines.

Outcrossing was reported to be a function of floral morphology and flowering behavior of both the A lines and the male parents (Oka and Morishima, 1967).The data in Table 5 showed also that the highest value for seed set percentage among the CMS lines was recorded on the Pusa13A line 48.18 and 48.80% in 2014 and 2015 seasons, respectively. This high rate of seed set percentage may be refered to the high stigma length, highest exertion ratio and high number of filled grains panicle^{-1} among the tested CMS lines, while the least value was recorded with IR68902A line 13.28 and13.50% in 2014 and 2015 seasons, respectively. This may be due to the low value of stigma width, narrow angle of spikelet opening, small exertion ratio and value of number of filled grains panicle^{-1}. Similar findings are reported by Viraktamath (1987) and Singh (2000).

TABLE 5. Mean of number of spikelets plant^{-1}, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and seed set % of some CMS, maintainer and restorer lines in 2014 and 2015 seasons

Line	Number of spikelets plant^{-1}		Number of filled grains panicle^{-1}		Number of unfilled grains panicle^{-1}		Seed set (%)	
	2014	2015	2014	2015	2014	2015	2014	2015
				A line				
IR68888A	246.83a	245.33b	61.88b	67.17b	184.96b	178.17b	25.09b	27.39b
IR68902A	247.08a	249.00a	32.83c	33.63c	214.25a	215.38a	13.28c	13.50c
IR70368A	212.43b	216.34d	67.08b	62.63b	145.35c	153.72c	31.54b	28.94b
Pusa13A	238.04a	241.17c	114.83a	117.71a	123.21d	123.46d	48.18a	48.80a
F test	**	**	**	**	**	**	**	**
L.S.D$_{0.05}$	11.03	3.13	25.06	17.31	21.9	17.82	10.16	7.13
L.S.D$_{0.01}$	16.72	4.74	37.96	26.22	33.18	27.00	15.4	10.8
				B line				
IR68888B	235.30a	221.33a	211.46a	200.00a	23.85	21.33	89.87	90.36
IR68902B	238.33a	212.00a	197.54a	197.67a	40.79	14.33	82.9	93.4
IR70368B	203.08c	186.00b	159.67b	163.00b	43.41	23	78.63	87.71
Pusa13B	225.35b	220.98a	189.33a	182.33a	36.02	38.64	84.08	82.53
F test	**	**	*	**	ns	ns	ns	ns
L.S.D$_{0.05}$	4.64	16.06	27.88	18.65	___	___	___	___
L.S.D$_{0.01}$	7.02	24.33	___	28.26	___	___	___	___
				R line				
PR1	211.45a	226.50a	176.42a	150.84ab	35.04	75.66	83.4	70.08
PR2	184.55c	161.29bc	153.17a	128.42bc	31.38	32.88	82.98	79.6
PR78	191.96b	199.54ab	159.88a	159.83a	32.08	39.71	83.27	80.1
G.179	118.04d	123.38c	105.46b	104.46c	12.59	18.92	89.35	84.35
F test	**	*	**	*	ns	ns	ns	ns
L.S.D$_{0.05}$	4.69	55.06	25	29.56	___	___	___	___
L.S.D$_{0.01}$	7.11	___	37.88	___	___	___	___	___

*, ** Significant at 0.05 and 0.01 levels, respectively. Number of filled grains panicle^{-1} and unfilled grains panicle^{-1} for CMS lines after pollination by its maintainer lines.

The grain yield is a very complex trait. It is multiplicative end product of several basic components of yield (Grafius 1959). Data in Table 6 showed highly significant differences among all lines in plant yield and panicle weight except for panicle weight of maintainer lines.The highest values for plant yield produced through outcrossing among CMS lines was recorded with Pusa13A 21.25 and 22.50 g in 2014 and 2015 seasons, respectively. This high yield for Pusa13A line was due to its superiority in stigma length, exertion ratio and seed set percentage resulting in a higher number of filled grains panicle^{-1} and heavy panicle weight. These findings were in close agreement with the earlier findings of Nuruzzamanet al. (2002), Li et al. (2002) , Faiz et al. (2006) and Saleem et al. (2008)

On the other hand, the least yield was obtained for IR68902A line 13.98 and 13.33g in the first and second seasons, respectively (Table 6) which is due to its shortage in panicle weight and seed set percentage resulting from the lower exertion ratio and number of filled grains panicle^{-1}. Similar findings were reported by Bagheri and Jelodar, (2010) and Rahimi et al. (2010).With respect to maintainer lines, Pusa13B recorded the highestplant yield value in both seasons of 37.28 and 40.96g, while IR68888B line recorded the least yield plant^{-1} of 27.29 and 27.51g,respectively (Table 6).Giza 179 as a restorer line has the highest plant yield of68.00 and 79.00g among restorer lines, while PR2 recorded the least value of (53.00 g) in both seasons, respectively. This indicates that Giza 179 with its high yield potential can contribute in producing superior yield of hybrid seeds through its restoring ability.

TABLE 6. Mean of plant yield and panicle weight (g) ofsome CMS, maintainer and restorer linesin 2014 and 2015 seasons.

Line	Panicle weight (g)		Plant yield (g)	
	2014	2015	2014	2015
		A line		
IR68888A	2.05c	2.09c	15.05b	14.58b
IR68902A	1.69c	1.61d	13.98b	13.33c
IR70368A	2.62b	2.44b	14.92b	14.92b
Pusa13A	3.22a	3.13a	21.25a	22.50a
F test	**	**	**	**
$L.S.D_{0.05}$	0.51	0.25	1.18	1.24
$L.S.D_{0.01}$	0.77	0.38	1.79	1.88
		B line		
IR68888B	4.41	4.53	27.29c	27.51c
IR68902B	4.59	4.01	36.27a	33.33b
IR70368B	4.63	4.87	30.78b	29.17c
Pusa13B	4.30	4.17	37.28a	40.96a
F test	ns	ns	**	**
$L.S.D_{0.05}$	___	___	2.07	3.67
$L.S.D_{0.01}$	___	___	3.13	5.56
		R line		
PR1	5.71a	5.05a	55.48c	66.20b
PR2	4.76b	4.84a	53.00c	53.00c
PR78	5.11ab	4.97a	59.83b	68.26b
G.179	2.91c	3.11b	68.00a	79.00a
F test	**	**	**	**
$L.S.D_{0.05}$	0.76	0.45	2.60	4.48
$L.S.D_{0.01}$	1.15	0.69	3.94	6.79

*, ** Significant at 0.05 and 0.01 levels, respectively

Among CMS lines, the heaviest panicle was recorded for Pusa13A line 3.22 and 3.13 g in 2014 and 2015 seasons, respectively, which could be due to its superiority in number of filled grains panicle^{-1} and seed set percentage. Thus, Pusa13A is a promising CMS line for the production of high hybrid rice seed yield. These findings were in close agreement with the earlier findings of Rao et al. (1996) and Mishra & Pandey (1998).On the other hand, the least panicle weight was obtained for IR68902A line 1.69 and 1.61g in the two seasons, respectively (Table 6) which is consequent of angle of spikelet opening, filament length, shortage in the number of filled grains because of lowest stigma width and seed set percentage. The data showed also that, the highest restorer line in panicle weight was PR1 5.71 and 5.05 g in seasons 2014 and 2015, respectively because of its superiority in characters of anther length, stigma length, stigma width, filament length, number of filled grains panicle^{-1} and other genetic constitution, while Giza 179 line showed the least panicle weight of 2.91 and 3.11g in the two seasons, respectively which may be due to its shortage in traits of anther length, stigma length, stigma width**,** filament length and consequently the number of filled grains panicle^{-1} (Watanesk, 1993 and Zhang et al., 1994).

Conclusion

This study concluded that, the floral traits differed significantly from line to line which affected significantly the plant grain yield. The highest CMS line in stigma length, exertion ratio, number of filled grains panicle^{-1}, seed set percentage, panicle weight and plant yield was Pusa13A line, so it is a good female line for hybrid rice seed production. The breeder should transfer these good characters in CMS breeding programs. The highest maintainer and restorer lines in the plant yield were Pusa13B line and Giza 179. The best restorer line in its floral traits which affected significantly the hybrid rice seed production and should be used in the breeding programs for breeding restorer lines is PR1 line.

References

Anonymous (2013) *Proceeding of the 17th National program Rice Research and Development Program Work shop.,* RRTC, ARC, Egypt, 50 pp.

Bagheri, N. and Jelodar, N.B. (2010) Heterosis and combining ability analysis for yield and related-yield traits in hybrid rice. *Int. J. Biol.,* **2**, 222-231.

Bassi, G., Joshi,D.P. and Gill, S.S. (1992) Studies on some important floret traits of CMS and restorer lines of hybrid rice. *Seed Research,* **20**, 74-77.

Bastawisi, A.O., Aidy, E.R., EL-Mowafi, H.F. and Maximos,M.A. (1998) Research and development for hybrid rice technology in Egypt. In: Advances of hybrid rice technology. *Proceeding of the 3rd International Symposium,* 14-16 Nov. Hyderabad, India: Manila (Philippines) 367-372.

Cheng, S.H., Zhuang, J.Y., Fan, Y.Y., Du., J.H., Cao, L.Y. (2007) Progress in research and development on hybrid rice, a super-domesticate in China. *Ann . Bot.* **100**, 959-966.

Neves, E.P. Guimaraes and Taillebois, J. (1989) Correlation between allogamic and agronomic traits in rice. *Int. Rice Res. News,* **14** (2), 12.

El-Badawy, O.A. (2009) Genetic studies on improvement of some restorer lines for cytoplasmic genetic male sterile (CMS) lines in rice. *MSc* Agric., Mansoura University., 79 pp.

Faiz, F.A., Sabar,M. , Awan, T.H., Tjaz, M. and Manzoor, Z. (2006) Heterosis and combining ability analysis in basmati rice hybrids. *J. Anim. PI. Sci.,* **16**, 56-59.

Govindraj, K. (1983) Studies on problems of hybrid rice with special reference to genetic and biometrical basis of male sterility and fertility restoration system. *Ph.D. Thesis,* ARI, New Delhi, India.

Grafius, J.E. (1959) Heterosis in barley.*Agron. J.*,**51**, 551-554.

Hasan, M. J., Rahman, UmmaKulsum, M. H. , Akter, A. and Shamsuddin,A. K. M. (2014) Comparative study of floral characteristics in the component lines of hybrid rice (*Oryza sativa* L.) , *Bangladesh J. Bot.* **43**(1), 1-8, 2014 (June)

Islam, M.A.,Mian, M.A., Rasul, G., Khaliq, Q.A. and Bashar, M.K. (2014) Estimation of specific combining ability (SCA) effects and per-se performances in some reproductive traits in rice (*Oryza sativa* L.). *Bangladesh Journal of Genetics and Plant Breeding,* **33**, 12-16.

Jayamani, P. and Rangaswamy, M. (1995) Floral characters influencing outcrossing in rice *Oryz,* **32**(1), 9-12.

Li, W., Zhang, J.Z., Zhang, G.Q. and Zuo, Q.F. (2002). Analysis of heterosis of main agronomic traits in indica-japonica lines of rice. *J. Southwest Agric. Univ.,* **24**, 317-320.

Mishra, M. and Pandey, M.P. (1998) Heterosis breeding in rice for irrigated sub-humid tropics in North India. *Oryza,* **35**, 8-14.

Nuruzzaman, M., Alam,M.F., Ahmed,M.G. , Shohael, A.M. ,Biswas, M.K. , Amin, M.R. and Hossain, M.M. (2002) Studies on parental variability and heterosis in rice. *Pak. J. Biol. Sci.,* **5**, 1006-1009

Oka, H.T. andNorishima, H. (1967) In: *The Ancestors of Cultivated Rice and Their Evolution.* Japan: Department of Applied Genetics, National Institute of Genetics., pp 145-154.

Pardhan, S.B. and Jachuck,P.J. (1993) Performance on Punjab CMS lines in cuttak , *India. Rice Res. Newsl.* 18:5.

Parmar, K.S, Siddiq, E.A. and Swaminathan, M.S. (1979) Variation in anther and stigma characteristics in rice. *Indian Journal of Genetics and Plant Breeding,* **39** (3),551-559.

Parmar, K.S., Siddiq, E.A. and Swamiuathan (I979b) Variation in anther and stigma characteristics in rice. *Indian J. Genet.* **39**, 551-559

Rahimi, M., Rabiei, B., Samizadeh, H. and Ghasemi, A.K. (2010).Combining Ability and Heterosis in Rice (*Oryza sativa* L.) Cultivars. *J. Agric. Sci. Tech.,* **12**, 223-231.

Rao, A.M., Ramesh, S. ,Kulkarni, R.S., Savithramma, D.L. and Madhusudhan, K. (1996) Heterosis and combining ability in rice. *Crop Improve.,* **23**,53-56

Sahai, V.N., Saran, S. and Chaudhary, R.C. (1987) Hybrid rice research in Bihar, *India. IRRN.,* **12**,23-23.

Saleem, M.Y., Mirza, I.I. and Haq, M.A. (2008) Heritability, genetic advance and heterosisin Line x Tester crosses of basmati rice. *J. Agric. Res.*, **46,**15-27.

Singh, R. (2000) Heterosis studies in rice using WA based CMS system for developing hybrids for Eastern Uttar Pradesh. *Armals Agric. Res.,* **21,** 79-83.

Srivastava, M.N. and Seshu, D.V. (1982) Heterosis in rice involving parents with resistance for various stresses.*Oryza,* **19**, 172-177.

Viraktamath, B.C. (1987) Heterosis and combining ability studies in rice (*Oryza sativa* L.) with respect to yield, yield components and some quality characteristics.*Ph.D. Thesis,* ARI, New Delhi, India.

Virmani, S.S. (1994) Heterosis and hybrid rice breeding. *Monogra Theor. Appl. Gent.* **22**. Springer-Verlag.

Virmani, S.S.,Khush, G.S. and Yang,R. (1980)Rice cultivars possessing some desirable floral traits influencing cross-pollination. *Int. Rice Res. Newsl.* **5**(4), 4-5.

Virmani, S.S., Chaudliary, R.C. and Khush, G.S. (1981) Current outlook on hybrid rice.*Oryza,* **18**, 67-84.

Watanesk, O.(1993) Heterosis and combining ability evaluation of cytoplasmic male sterile (A) lines and restorer (R) lines. *Int Rice Res. Not.* **10**, 5-6.

Zhang, Q., Gao, Y.J. , Yang, S.H., Ragab, R.A., Maroof, M.A.S. and Li, Z.B. (1994) A diallelanlysis of heterosis in elite hybrid rice based on RFLPs and micro satellites. *Theor. Applied Genet.* **89**(2-3),185-92.

(*Received:*22 /10 /2017 ;
*accepted:*26 /12 /2017)

دور الصفات المورفولوجية أعلى عقدة الورقة العلم و الزهرية في إنتاج تقاوي الأرز الهجين

عبد العزيز جلال عبدالحافظ[1], السيد فاروق علي عرفات[1]و أحمد حسن مطر[1]
[1]قسم المحاصيل- كلية الزراعة- جامعة كفر الشيخ و[2]مركز البحوث والتدريب في الأرز- سخا – كفر الشيخ - مصر

أجريت تجربتان حقليتان في المزرعة البحثية لمحطة البحوث الزراعية بسخا وذلك لدراسة الصفات الزهرية والمحصولية لأربعة سلالات عقيمة الذكر وآبائها المحافظة على الخصوبة بالإضافة لأربعة آباء معيدة للخصوبة خلال موسمي الزراعة ٢٠١٤و ٢٠١٥. من المعلوم أن الصفات الزهرية للآباء المستخدمة في إنتاج تقاوي الأرز الهجين مهمة جدا في إنتاج تقاوي الأرز الهجين خصوصا في نظام الثلاث سلالات المستخدم في هذه الدراسة. إن طول كلا من المتك و الميسم وخيط المتك واتساع عرض المتك والميسم بالإضافة إلى نسبة بزوغ السنبلة العالية وزاوية انفتاحها تعد صفات هامة لزيادة معدل التلقيح الذي بدوره يزيد من استعداد الحبة و إنتاج تقاوي الأرز الهجين. هذه الدراسة تم تنفيذها للمساهمة في اختيار أفضل السلالات العقيمة الذكر سيتوبلازميا و المحافظة على الخصوبة والمعيدة للخصوبة وذلك لاستخدامها في إنتاج تقاوي الأرز الهجين معتمدة على صفاتها الزهرية فوق عقدة الورقة العلم بالإضافة إلى ذلك فإنه يمكن استخدامها في برامج التربية لتحسين الصفات الزهرية للسلالات الأخرى التي تستخدم كآباء جيدة في تربية الأرز الهجين وإنتاج التقاوي. خلاصة الدراسة - فقد وجدنا انه من بين السلالات العقيمة الذكر سيتوبلازميا المدروسة كانت السلالة Pusa13A هي أفضل سلالة في صفات طول المتك ونسبة بزوغ السنبلة, عدد الحبوب الممتلئة بالسنبلة, نسبة استعداد الحبة, محصول النبات و وزن السنبلة, بينما كانت السلالة المحافظة علي الخصوبة Pusa13B هي الأفضل نظرا لصفاتها المتميزة مثل صفات طول المتك و طول خيط المتك الجيد والنسبة العالية لبزوغ السنبلة,عدد الحبوب الممتلئة بالسنبلة ومحصول النبات. بالنسبة للسلالات المعيدة للخصوبة فإن السلالة PR ١ كانت هي الأفضل من بينهم في الصفات الزهرية مثل طول المتك و طول الميسم, عرض الميسم وطول خيط المتك بالإضافة لصفات عدد السنيبلات لكل نبات,عدد الحبوب الممتلئة بالسنبلة ووزن السنبلة.